

REMARKS

Claims 1-4, 6, and 8-12 are pending in the application, with claims 1-3 being currently amended.

Independent claims 1-3 have been amended to more clearly define the invention over the art of record. In particular, claims 1-3 now specify that the first concave portion is formed penetrating at least the second semiconductor layer from a primary surface, which is a top surface, of the second semiconductor layer, with claim 2 further reciting that the first concave portion is formed to a distance that allows a quantum mechanical tunnel effect with the two dimensional carrier to be obtained. [underlining for emphasis]. In addition, independent claims 1-3 now recite that "the first semiconductor material and the second semiconductor material generate a piezoelectric polarization by distortion that is generated by the difference in the lattice constant between the first semiconductor layer and the second semiconductor layer". Claims 1 and 2 also further recite that "the side surface of the first concave portion is inclined against the interface so that the inclination changes the thickness of the second semiconductor layer", and claim 3 recites that the side surface of the first concave portion "is inclined against the second interface between the third semiconductor layer and the second semiconductor layer". Finally, the phrase "the primary surface of the second semiconductor layer faces the first interface between the first semiconductor layer and the second semiconductor layer" has been deleted from claim 3. Support for the amendments can be found throughout the specification. No new matter has been added.

Claim Objections

In the Official Action, claims 2 and 3 are objected to because of the following informalities.

Concerning previously pending claim 2, Examiner states this claim recites the limitation "and a distance that allows a quantum mechanical tunnel effect with the two

dimensional carrier to be obtained". Examiner believes that there is a typographical error and that Applicants intend "and is formed to a distance that allows a quantum mechanical tunnel effect with the two dimensional carrier to be obtained". See Official Action at Paragraph 3. In view thereof, Applicants have amended claim 2 to include the underlined phrase "is formed to" to overcome the objection.

Concerning previously pending claim 3, Examiner states this claim recites the limitation "a first interface between the third semiconductor layer and the second semiconductor layer" as well as "the first interface between the first semiconductor layer and the second semiconductor layer". Examiner alleges that the claim renders indefinite between which two layers the interface is formed. See Official Action at Paragraph 3. In view thereof, Applicants have amended claim 3 by deleting the limitation "the primary surface of the second semiconductor layer faces the first interface between the first semiconductor layer and the second semiconductor layer" to overcome the objection.

Accordingly, the above objections are overcome and must be withdrawn.

35 U.S.C. §112, 2nd Paragraph -- Rejection of Claims 1-4, 6, and 8-12

In the Official action, claims 1-4, 6, and 8-12 stand newly rejected under 35 U.S.C. §112, second paragraph, as being indefinite. In particular, claims 1-4, 6, and 8-10 recite the limitation "a primary surface of the second semiconductor layer". Despite comment [D1] that asks "Is this really a 112? Isn't this similar to him saying "first surface"?", Examiner states that is unclear as to which surface: top, bottom, or side, is the primary surface. See Official Action at Paragraph 4.

In view of the rejection, independent claims 1-3 have been amended, as discussed above, to more clearly define Applicants' invention. In particular, claims 1-3 now specify that the first concave portion is formed penetrating at least the second semiconductor layer from a primary surface, which is a top surface, of the second semiconductor layer. As a result, Applicants submit

that the §112 rejection is overcome and must be withdrawn.

35 U.S.C. §102 -- Rejections of Claims 1, 3, and 11

In the Official Action, previously pending claims 1, 3 and 11 stand rejected under 35 U.S.C. §102(b) as being anticipated by Peatman et al. ("A Novel Schottky/2-DEG Diode for Millimeter- and Submillimeter-Wave Multiplier Applications" ("Peatman"). See Official Action at Paragraph 5. Applicants respectfully disagree, particularly in view of independent claims 1 and 3, as now amended.

It is well established that "a claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). For the following reasons, Peatman clearly fails to teach each and every element of Applicants' semi-conductor device as recited in independent claims 1 and 3.

Claims 1 and 3 each now require that the first semiconductor material and the second semiconductor material generate a piezoelectric polarization by distortion that is generated by the difference in the lattice constant between the first semiconductor layer and the second semiconductor layer.

By way of background, a special crystal structure (e.g., a hexagonal crystal structure that is represented by a nitride semiconductor material) having a low symmetry and an ionicity generates a piezoelectric polarization by distorting the crystal structure. When a second semiconductor layer is formed on a first semiconductor layer, the lattice constant of the first semiconductor layer and the lattice of the second semiconductor layer are different. It is known that a magnitude of the piezoelectric polarization depends on a thickness of the second semiconductor layer. And it is known that a two-dimensional carrier, which is generated in the vicinity of the interface, is influenced by not only a spontaneous polarization of asymmetry of crystal structure, but also the piezoelectric polarization.

With that in mind, the invention may be characterized by at least the following:

(1) A first concave portion, which is penetrating the second semiconductor layer, is formed. A side surface of the first concave portion is inclined. A Schottky electrode is formed on a bottom surface and a side surface of the concave portion.

(2) A little amount of (or no) two-dimensional carrier is generated at a region in the vicinity of the two-dimensional carrier, because the second semiconductor layer is thin. Therefore, a depletion can occur easily and withstanding pressure can be improved.

In a region where there is not formed a concave portion or a region where it is relatively far from the concave portion, a thickness of the second semiconductor layer is relatively large. Therefore, the two-dimensional carrier is generated easily, and on-resistance of a semiconductor device can be improved.

In other words, in the claimed invention, the first semiconductor and the second semiconductor, which generate the piezoelectric polarization, are formed, and the thickness of the second semiconductor is changed by inclining the side surface of the first concave portion.

Concerning Peatman, this reference discloses "a pseudomorphic $\text{Al}_{0.25}\text{Ga}_{0.75}\text{As}/\text{In}_{0.15}\text{Ga}_{0.85}\text{As}/\text{GaAs}$ structure" (III. PROTOTYPE FABRICATION AND RESULTS). However, this structure of Peatman does not generate a piezoelectric polarization, as now required by claims 1 and 3. Thus, Peatman at least fails to teach (or suggest) that a first semiconductor material and a second semiconductor material generate a piezoelectric polarization by distortion that is generated by the difference in the lattice constant between the first semiconductor layer and the second semiconductor layer, as well as the effect of (2) above mentioned. Accordingly, the anticipation rejections based on Peatman must be withdrawn.

35 U.S.C. §103 -- Rejections of Claims 2, 4, 6, and 8-12

In the Official Action, claims 2 and 8-11 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Peatman in view of Kanazawa (JP Application Publication 03-016179)

("the '179 publication"). *See* Official Action at Paragraphs 6 and 9. Applicants respectfully disagree.

To establish *prima facie* obviousness of a claimed invention, it is certainly well established that all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974). To that end, even assuming *arguendo* that one skilled in the art would combine Peatman and the '179 publication, the combination still fails to disclose or suggest Applicant's invention as recited in claim 1, as explained below.

Like independent claims 1 and 3 above, claim 2 now requires that the first semiconductor material and the second semiconductor material generate a piezoelectric polarization by distortion that is generated by the difference in the lattice constant between the first semiconductor layer and the second semiconductor layer.

Peatman has been discussed above. Those same arguments apply equally with respect to this rejection. And the '179 publication fails to correct the deficiencies of Peatman. Upon review of the '179 publication, this reference discloses forming an $\text{Al}_x\text{Ga}_{1-x}\text{As}$ active layer on a GaAs substrate. And, similar to Peatman, the material of the '179 publication does not generate a piezoelectric polarization, as now required by claims 1. Thus, the combination of Peatman and the '179 publication at least fails to render obvious that a first semiconductor material and a second semiconductor material generate a piezoelectric polarization by distortion that is generated by the difference in the lattice constant between the first semiconductor layer and the second semiconductor layer, as well as the effect of (2) above mentioned. Accordingly, the rejections based thereon must be withdrawn.

Finally, claims 4 and 6 stand rejected under 35 U.S.C. §103(a) as being unpatentable either over Peatman in view of Patel et al. (UK Patent Application Publication 2 279 806) ("the Patel '806 publication") or over Peatman in view of the '179 publication, and further in view of the Patel '806 publication. *See* Official Action at Paragraphs 7 and 8. And, claim 12

stands rejected under 35 U.S.C. §103(a) as being unpatentable over Peatman in view of Patel et al. U.S. Patent No. 5,742,077 ("the Patel '077 patent") or over Peatman and Kanazawa and further in view of the Patel '077 patent. *See* Official Action at Paragraphs 10 and 11.

Claims 4, 6, and 12 depend from any one of independent claims 1 to 3. Therefore, Applicants submit that the Examiner's rejection of dependent claims 4, 6, and 12 is in error for at least the same reasons discussed above with respect to claims 1 to 3. In addition, it is further noted that Patel uses an "AlGaAs/GaAs structure", which like Peatman and the '179 publication, does not generate a piezoelectric polarization.

No Prima Facie Case

For all of the above reasons, it is submitted that the claims as pending are patentable over the cited references, and that no prima facie case of obviousness was made before, nor would be applicable here over that same art. In that regard, the additional art cited by Examiner as being of interest is submitted not to change the situation.

Conclusion

As a result of the remarks given herein, Applicants submit that the rejections of the pending claims have been overcome. Therefore, Applicants respectfully submit that this case is in condition for allowance and requests allowance of the pending claims.

If Examiner believes any detailed language of the claims requires further discussion, Examiner is respectfully asked to telephone the undersigned attorney so that the matter may be promptly resolved. Applicants also have submitted all fees believed to be necessary herewith. Should any additional fees or surcharges be deemed necessary, Examiner has authorization to charge fees or credit any overpayment to Deposit Account No. 23-3000.

Respectfully submitted,
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